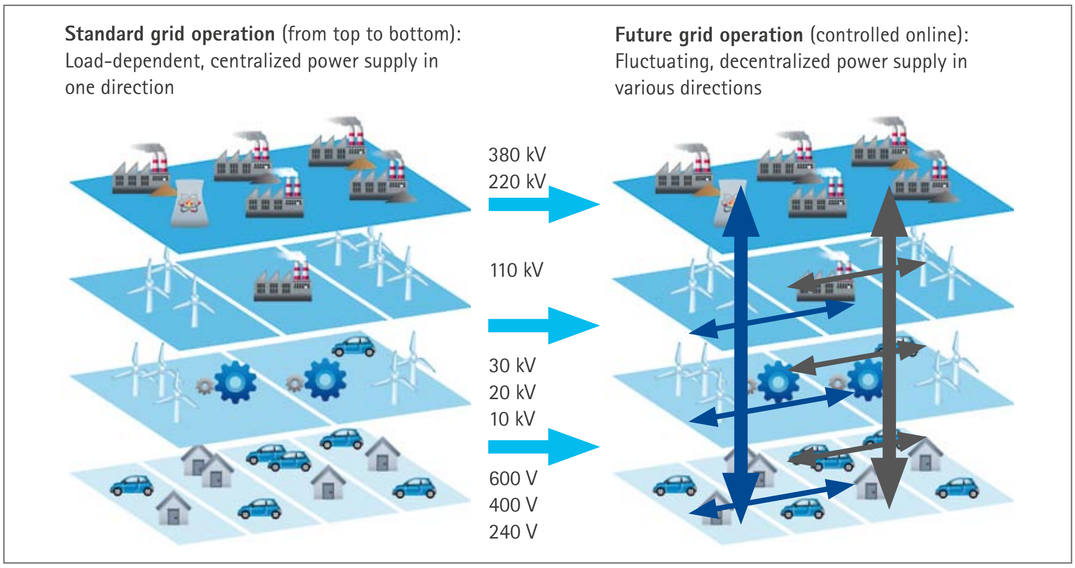
Intelligent system solutions for distribution networks

The future of electricity networks – smart grids

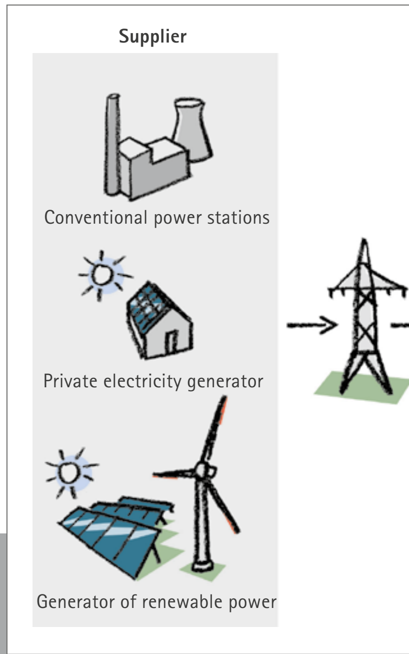


Decentralized energy supply spreading quickly

In parallel with the process of liberalization, the last few years have also witnessed a huge increase in decentralized energy supplies. This includes both off-grid and on-grid operation of small supply units. The generation units can be operated at the site of use and are then either used to directly cover requirements or the electricity produced there is made available to the supply system.

This development has been accelerated by legislation to give priority to renewable energies (Renewable Energy Law). This law came into force in 2000 and stipulates that grid operators must link to, accept and pay plants to generate electricity from renewable sources. Since most such electricity comes from decentralized units, there has been a partially subsidized increase in this area. This situation has brought with it new requirements for the absorbing electricity network as the load flow direction may now reverse and do so with huge fluctuations. If electrical energy is distributed in the usual way "from top to bottom", there are now more and more generators feeding into the grid starting at the medium voltage level.

What is a smart grid?
A smart grid is an electricity network which intelligently coordinates the actions of all connected users – producers, consumers, storage units – in order to ensure efficiency in an environmentally sustainable, economically viable and reliable electricity supply.



Development and trends – from the standpoint of a smart grid operator

Change on the energy markets – change in infrastructure

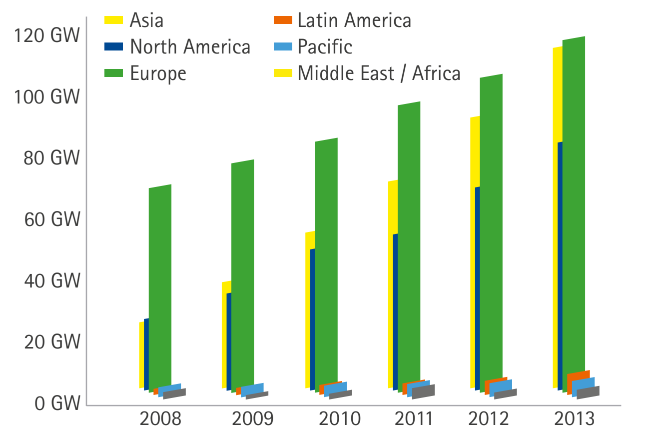
The energy markets are undergoing fundamental change. At the end of the 21st century, we will have renewable energy systems where load is dictated by generation, renewable sources of energy are the main player and energy efficiency measures start to become effective.

Three trends are already becoming apparent today:

- Liberalization of the energy markets is resulting in the unbundling of what were once vertically integrated structures of generation.
- Huge growth in decentralized energy generation, especially renewable energy
- Need for efficient use of energy to reduce greenhouse gas emissions

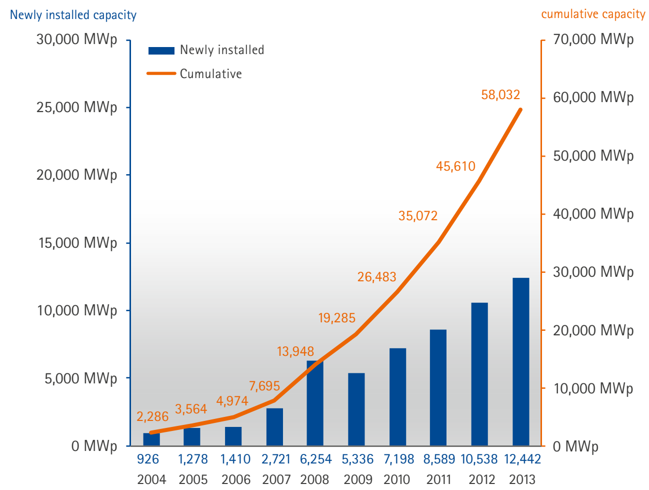
Coupled with the world's ever-growing appetite for energy, this is placing much greater requirements on the grid and its equipment – affecting distribution networks in the future too.

Expected Growth of Wind Energy

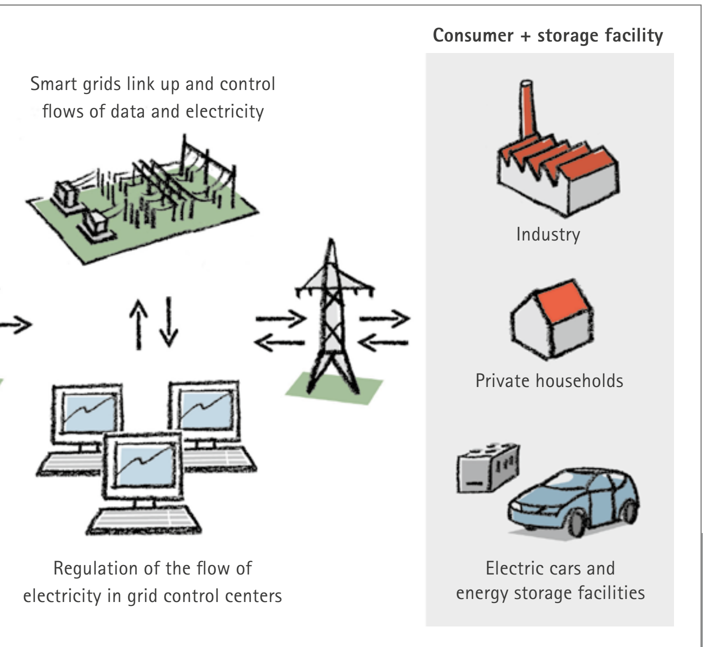


Source: DCTI Solar Energy Study

Expected Growth of Photovoltaic Installations



Source: DCTI Solar Energy Study



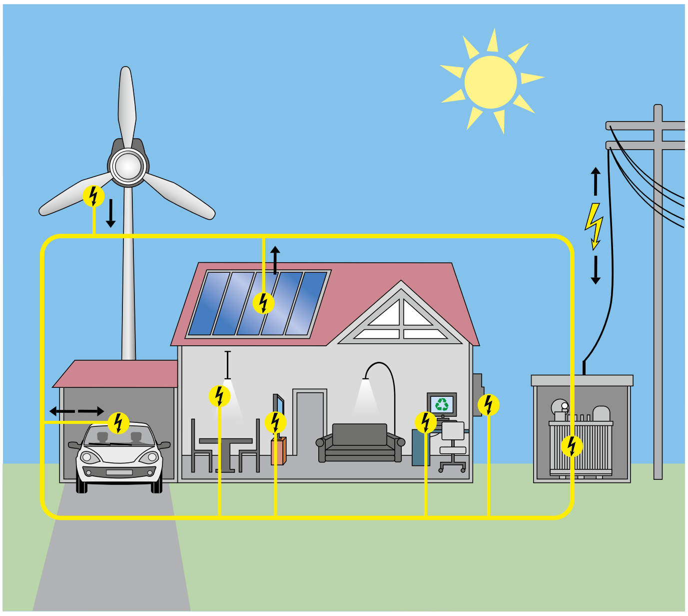
Increasing demand for energy – changes to the grid structure

Intelligent regulation in distribution networks

Intelligent grid regulation will be needed in the distribution networks of the future to balance production and consumption, to maintain a secure supply and to comply with voltage bands (to prevent electrical equipment from being destroyed); communicative links are important for this reason if no other. Advances in information and telecommunications technology are evolving rapidly. The Internet and wireless transmission technologies such as GSM and the associated applications have now become the norm. There is one obvious way in which this potential can be used to address the complex requirements existing in the generation, distribution and supply of energy.

Information and communication technologies (ICT) may have an important role to play in reducing energy consumption and optimizing the energy system because they can be used to address fundamental problems in the electricity sector resulting from fixed bonding to the grid and the fact that electricity cannot be stored: **In order to avoid bottlenecks and system overloads, supply must be able to respond at all times to the demand resulting from the decentralized decisions made by households and businesses. It is important to remember that both too great and too low a demand can trigger an instable system status.**

No exchange or a slow exchange of information and/or links between information result in production and consumption not being sufficiently matched. In the future, new products and systems must therefore take account of the needs of both communication and load flows. Huge growth in the number of decentralized suppliers, such as roof-mounted photovoltaic systems, mini combined heat and power plants (CHP) or small wind farms results in greater voltage fluctuations in the distribution network and may even violate the permitted voltage band. Harmonic currents from electronic consumers and voltage imbalances are other aspects which will increasingly have to be taken into account.

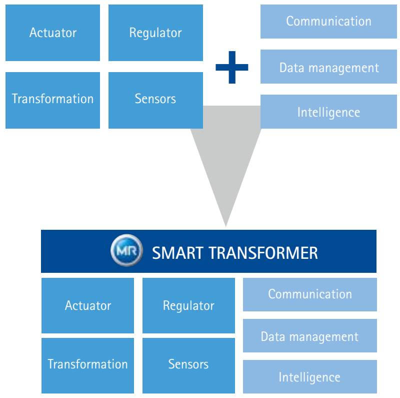


One solution: The controllable local grid transformer

The problem of voltage fluctuations and band violations can be solved using a controllable local grid transformer for example. Maschinenfabrik Reinhausen (MR), with its expertise as a global market leader in voltage regulation, focused on solving this issue at an early stage and realized that any approach needed to offer the operator the following benefits:

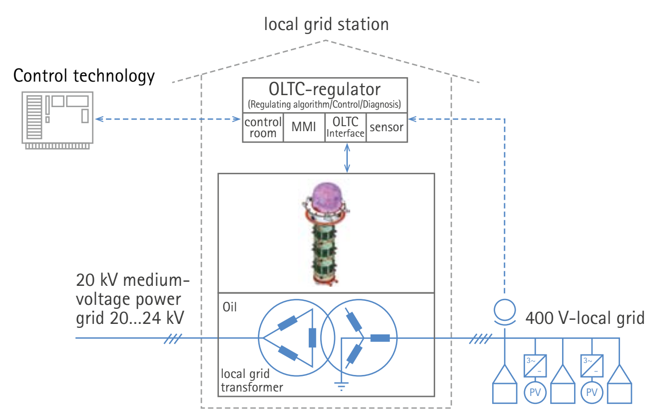
- Compliance with the permissible voltage limits
- Optimized use of existing reserves
- Grid extension measures can be deferred or avoided altogether.
- Greater potential for the integration of decentralized supplies is made possible.

MR Smart Transformer – the systematic response

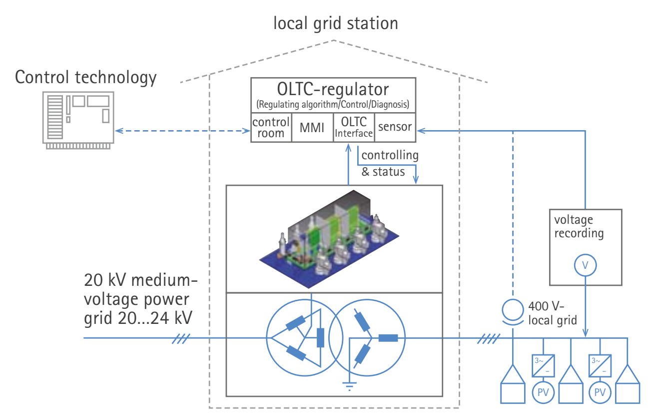


The MR Smart Transformer features transformation, actuator, regulator, sensor, communication, data management and intelligence system components. This level of the MR iPOWER system is intended as a minimal unit for use in local grid stations. With the addition of a medium- and low-voltage connection, this is the independent, regulated equivalent of today's uncontrolled local grid station.

Classical actuator principle



Hybrid actuator concept



Actuators: Two technical solutions available

A controlled transformer is the centerpiece of the station. To date MR has equally pursued two technical solutions at various stages of development:

- **Classic principle of actuators based on proven oil switch technology in use for decades**
  On the basis of proven tap-changer technology at the high and maximum voltage level, Maschinenfabrik Reinhausen has managed to now make this technology suitable for use in local grids. By slightly increasing its length and height, the transformer now covers applications up to the 630 kVA connection class.

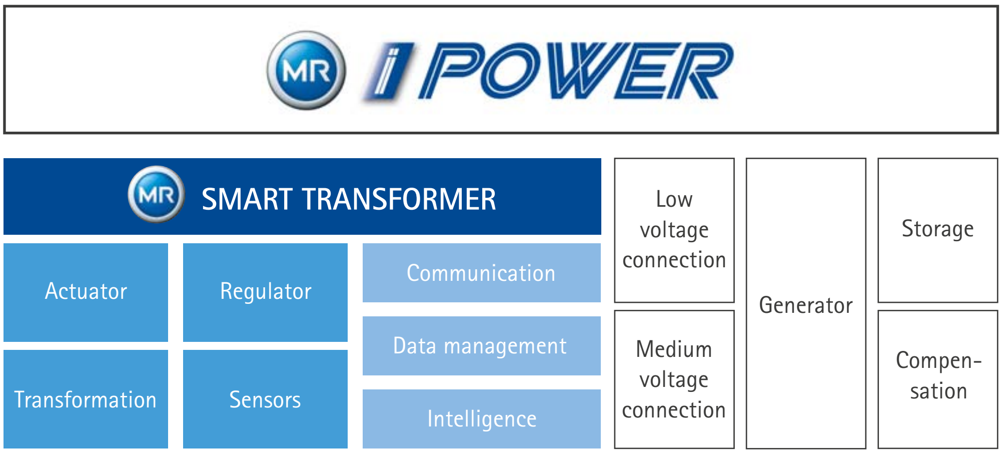
- **Hybrid principle as a combination of semi-conductor switching element and mechanical main switching contacts**
  Innovative combination of semi-conductor switching elements and mechanical contacts means that less space is needed in the transformer. Simply swapping the transformation and actuator unit makes this a great update solution for existing stations.

Special actuator regulation (voltage regulation) is needed for tap changes. This comprises:

- Regulation unit for monitoring voltage and controlling the functions of the conventional actuator
- Regulation unit for monitoring voltage and controlling the functions of the hybrid actuator

Depending on the application, additional sensors are needed to monitor the station functions and/or to implement a self-sufficient station.

The complete solution:
the MR iPOWER system



MR iPOWER system

In addition to the system components of the MR Smart Transformer, the MR iPower system also comprises the following components:

- Low-voltage connection
- Medium-voltage connection
- Energy storage system (e.g. battery storage)
- Compensation system (MR Power Quality Management)
- Self-sufficient generation unit (e.g. renewable energy generators)

In both variants, the system functions as the generation unit which either acts totally self-sufficiently as the generator (e.g. use when fully off grid or use in areas with poor infrastructures, including use in emergency areas for disaster operations) or only with one grid connection for covering peaks in consumption which cannot be provided by the unit itself. Use and specification of the compensation and/or storage unit depends on the generation unit used and/or the external application.

Based on current technical standards, the following system components are available as options:

- Micro photovoltaic systems (PV)
- Micro wind turbines (WT)
- Systems for the generation of biogas, which is implemented in the combined heat and power (CHP) module.
- Systems using geothermal energy
- Heat pumps

MR iPOWER project in Oberursel

Working jointly with Süwag Energie (Frankfurt), the first complete MR iPOWER system was commissioned as a 20 kV pilot plant at Oberursel on a site belonging to MR's subsidiary Messko GmbH.

This comprises:

- MR iPOWER system
- Wind energy system of 6 kWp (grid)
- Photovoltaic system of 20 kWp (grid)
- Combined heat and power (installed 08/2011)
- Battery storage system (installed 08/2011)
- Electric car charging station

The iPOWER system will on the one hand supply Messko GmbH with energy and on the other hand feed excess energy produced to the Süwag grid.

Here are some of the physical parameters to be monitored by way of example:

- Oil temperature of transformer
- Winding temperature of transformer
- Oil quality level of transformer
- Oil flow within transformer and attached cooling system
- Current sensors
- Voltage sensors

DGA monitoring (gas-in-oil monitoring) can be fitted as an option and in large units. The analyzer is used to extract and measure gases dissolved in the transformer's insulation liquid. Based on the trends indicated, a statement can be made on the transformer's errors, maintenance cycles and service life. The individual pieces of physical information are merged in a central data manager.

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