Cluster Leistungselektronik

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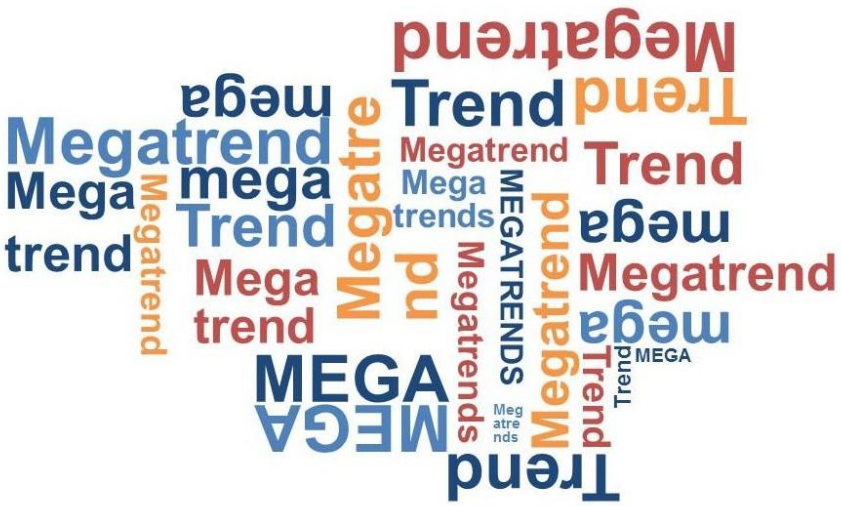
Position Paper

What Drives Power Electronics in the New Decade

- Global megatrends in society and their mutual impact with Power Electronics



1. Main power electronics drivers in the last two decades

The starting situation coming from the 20th century was that power electronics was a very traditional topic in electrical engineering with key application areas in industry drives and railway traction in the medium to high power world, as well as in various kinds of power supplies.
Power electronics was existing in a niche without major public awareness outside the closed community of power electronics experts. Public research programmes hardly addressed power electronics topics directly.

This situation has changed when it became obvious that power electronics is a key technology for increased energy efficiency along the full chain from generation, transmission & distribution up to the use of electric energy. Furthermore, it is an enabler for the grid integration of renewable energy sources e.g. from photovoltaics and wind power. E-mobility has been boosting this development as power electronics is a key technology for e-mobility on the vehicle side as well as on the grid side. As a consequence of this change, power electronics has moved out of the niche into the focus of public awareness, regarding public funding programmes for research & innovation in Europe and also regarding its attractiveness for students.

Now the question is what will drive power electronics in the new decade up to 2030 and beyond? The approach used in this ECPE Position Paper is to derive such drivers from global megatrends in society.

2. Global megatrends in society

According to PwC (/1/), megatrends are macroeconomic and geostrategic forces that are shaping the world. They are factual and often backed by verifiable data. By definition, they are big and include some of society's biggest challenges - and opportunities.
According to Frost & Sullivan (/2/), megatrends are global**,** sustained**,** macroeconomic forces of development that affect business, economies, societies, cultures, and personal lives. In essence, these trends - such as urbanization or connectivity - will define our future world.

Figure 1 shows five main global megatrends in society, the graph is a synthesis from several sources (/1/, /2/, /3/). In the following chapter the rationales of the five identified megatrends are presented.

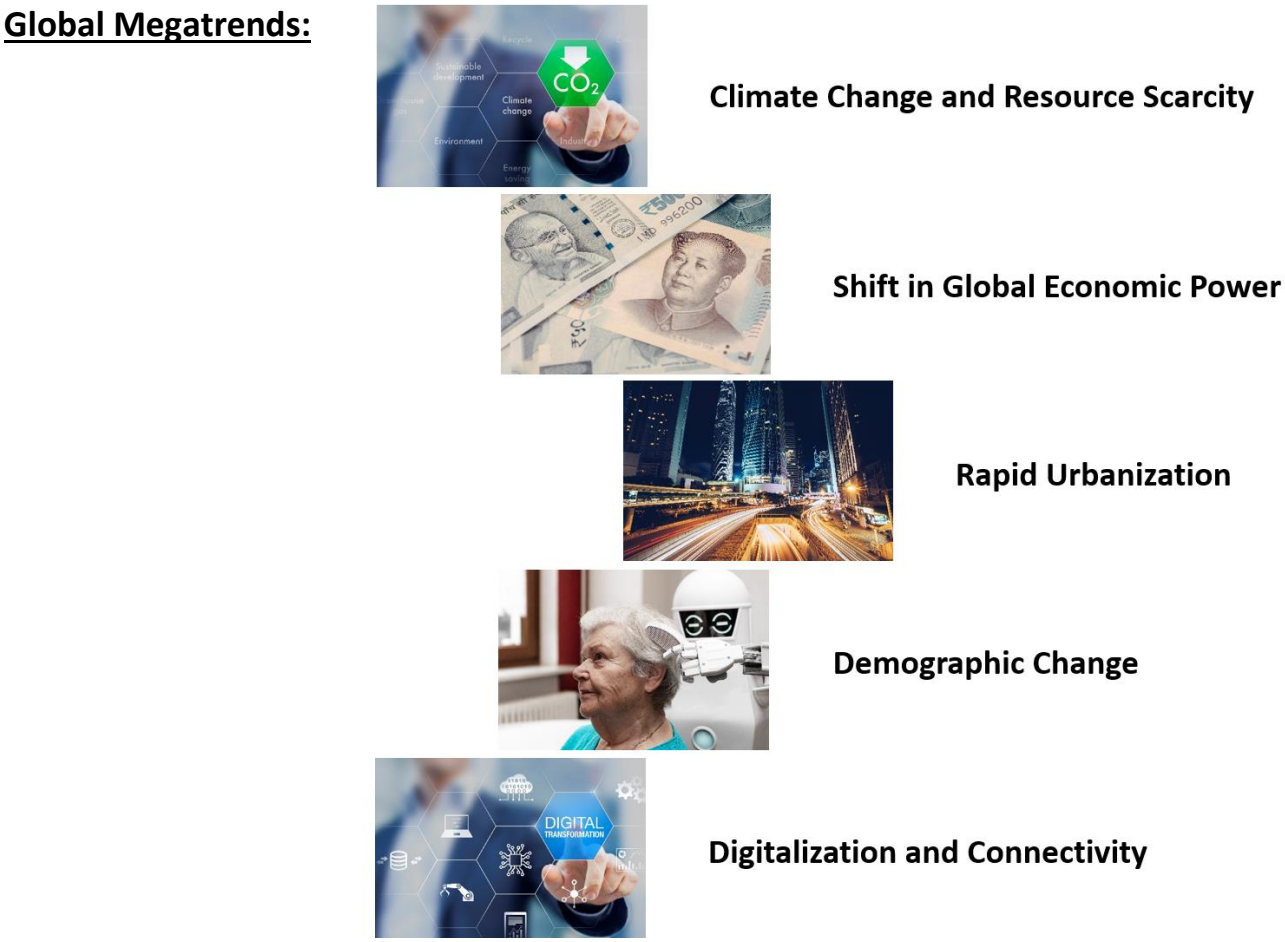


Fig. 1 Global megatrends in society, (pictures: iStockphoto by Getty Images)

2.1 Climate change and resource scarcity

Growth in global population and prosperity also increases the demand for natural resources such as water, energy, minerals and metals and also food. There are, however, limited quantities of resources available. Furthermore, emissions of green-house gases from this large-scale consumption of resources constitutes a threat to our immediate environment. The global warming already has severe consequences. Our planet no longer seems capable of supporting this increased consumption. The economic impact will be amplified by the interdependence between climate change and resource scarcity, with a large impact on food and water issues.

2.2 Shift in global economic power

Driven by strong growth in emerging countries, an economic power shift from west to east is taking place. The shift in global economic power has created wealth in previously poorer regions and changed supply chain logistics. The growth of China to a global economic superpower which is on the way to gain technological leadership can be presently observed.

2.3 Rapid urbanization

Cities are becoming increasingly more important in the global economy. Today, there is a discernible acceleration of this urbanization, with an increasing number of so-called megacities with more than 10 million inhabitants. In 2030, sixty percent of the world population will live in urban regions.

2.4 Demographic change (elderly society)

While population growth in some western countries is decreasing, there will be an additional billion people in the world by 2025. In Europe, we are growing older and we are having fewer children. This elder society has a variety of consequences e.g. in the medical area, in the pension scheme, in the world of work, as well as in the buying and leisure behaviours.

2.5 Digitalization and connectivity

Digitalization involves for example big data, cloud computing, artificial intelligence, advanced robot technology, internet of things, mobile internet and mobile payment, advanced manufacturing technologies including 3D printing or advanced connectivity e.g. in vehicles or in production control. The digital transformation will change business models, the way of manufacturing and retail as well as the world of work.

3. Megatrends and power electronics: importance and mutual impact

In the following chapter both aspects are considered: what power electronics can contribute to the respective megatrend and how power electronics is affected by the megatrend with benefits or possible negative impacts. The key question to be answered is how these five main global mega-trends drive power electronics?

3.1 Power electronics & climate change and resource scarcity

The contributions of power electronics to the megatrend of climate change and resource scarcity are manifold:

- **Sustainable Energy Supply by Renewables**
  - Grid integration of PV and wind power
  - Power transmission (e.g. with HVDC High Voltage DC lines)
  - Power distribution (local grids with bidirectional flow of power, integration of energy storage into the grid)
  - Grid control and global stability (smart inverters, integration of energy storage, reduce harmonic distortions and improve power quality measures)
  - Grid integration of EV (fast) charging based on renewables

- **Improved Energy Efficiency**
  - On component level with low-loss wide bandgap (WBG) devices and new materials to advance passive components
  - On module and converter level with new topologies, proper circuit design to eliminate distributed parasitics and digital control. Advanced integration technologies including power embedding and smart thermal management to fully exploit the potential of the new devices on converter and system level.
  - On system/application level by:
    - Elimination of redundant power conversion steps by introducing efficient DC grids e.g. for buildings, industry plants, ships and airplanes
    - Introducing power electronics where it is not used today because it is too bulky or too expensive. Key enablers are miniaturization, system integration and cost reduction.
    - Smart solutions on system level: energy savings by smart systems based on both, power electronics and information & communication technologies (ICT).

- **More/Full Electric Society**
  - Overall transition towards a sustainable more electric (or full electric) society driven by renewable energy sources (e.g. with electric bikes, scooters, cars, trucks, trains, ships and air transport) where power electronics is everywhere.

Conclusions:
- The impact of power electronics on the reduction of CO_2 emissions is major
- Cost is key to make CO_2 reduction measures affordable
- CO_2 reduction to stop the climate change will be the main driver for power electronics in the new decade

3.2 Power electronics & shift in global economic power

There are major challenges for power electronics industry and also for research in Europe related to the ongoing shift in global economic power from west to east. The enormous resources (engineering manpower and money) China is presently investing in power electronics research, development and innovation will soon lead to technology parity with Europe, Japan and US. China is targeting technology leadership for key industries e.g. semiconductor technologies, future transportation systems and all topics related to reliable and sustainable energy supply and communication systems including the smart infrastructure measures. What can we do to protect our strong position in Europe in research, technology and industrial business?

- Be innovative and stay at the forefront of key technologies
- Act fast and flexible e.g. move to niche applications with higher added value
- Position close to application and customer taking benefit out of system know-how
- Regain leadership in transportation systems with alternative propulsion concepts
- Build-up an efficient and reliable energy supply infrastructure based on renewable sources
- Maintain leadership in factory automation and medical equipment industry
- Focus on technologies for smart cities and clean environment

3.3 Power electronics & rapid urbanization

The contributions of power electronics to the megatrend of urbanization:

- Smart buildings: smart homes, offices and industry plants e.g. with DC grids, ICT control
- Electric and autonomous mobility including the integrated traffic system on the road, rail, water and in the air
- Smart transport including the logistics of goods e.g. related to the transition in retailing due to internet shopping

3.4 Power electronics & demographic change

The contributions of power electronics to the megatrend of demographic change:

- Service robots to replace simple labour or to allow elderly people to live longer at home
- Exoskeletons as a support for older workers, e.g. to lift heavy parts in production, or to support elderly or disabled people in walking
- Health care robots
- E-scooter for better mobility of elderly people
- Lifts, escalators and conveyor belts (for people)
- Electrical training equipment to train the locomotor system

3.5 Power electronics & digitalization and connectivity

The interactions and mutual impacts of power electronics and the megatrend of digitalization and connectivity are manifold:

- Smart, self-learning systems in industry e.g. in automation
- In industry: smart inverters and connected distributed drives
- Condition & health monitoring (industry 4.0)
- Smart grids including energy storage with smart battery management systems, digital control and smart meters
- Smart homes, offices and stores incl. DC microgrids
- Highly efficient power supplies for the digital infrastructure e.g. for data center, base stations
- Smart charging of EVs for bidirectional vehicle-to-grid (V2G) integration
- Virtual prototyping (coupled multi-domain simulations, digital twin)
- Design automation in power electronics to obtain higher efficiencies and more compact designs at lowest costs
- Security solutions for the connected world

4. Conclusions

Two key drivers for power electronics have been clearly identified for the new decade: **CO_2 reduction to stop the climate change, as well as digitalization**.
Additional impacts will arise from the further megatrends of urbanization as well as the demographic change. The shift of global economic power and especially the transition of China´s role from a customer to a competitor will challenge power electronics industry in Europe.

5. References

/1/ PwC (www.pwc.co.uk/megatrends, www.pwc.nl/en/topics/megatrends.html)

/2/ Frost & Sullivan (www.frost.com/consulting/key-client-issues/mega-trends/)

/3/ Victoria Scarborough, ´How megatrends drive innovation´ http://www.coatingstech-digital.org/coatingstech/march_2019/