4E

Energy Efficient End-use Equipment
International Energy Agency

ENERGY EFFICIENCY POLICY BRIEF

Wide Bandgap Industrial Variable Speed Drives Research Roadmap

EMSA8

PECTA4

Statement of Platform Objectives

The **4E Electric Motor Systems Platform (EMSA)** promotes the opportunities for energy efficiency in electric motor systems by disseminating best practice information worldwide. It supports the development of internationally aligned test standards and policies to improve the energy performance of new and existing motor systems.

The **4E Power Electronic Conversion Technology Platform (PECTA)** engages with research, government and industry stakeholders worldwide to monitor development, assess the benefit of utilising WBG technology and build the foundation for suitable policies.

This Policy Brief highlights the importance of wide bandgap power semiconductors in industrial variable speed drives and introduces the Research Roadmap developed by EMSA in cooperation with PECTA. The Research Roadmap aims to facilitate the adoption of this new technology by addressing key challenges with dedicated research topics over the course of the next few years.

Observations for Policy Makers

- The use of wide bandgap (WBG) power semiconductor devices, based on Silicon Carbide (SiC) or Gallium Nitride (GaN), offers a significant reduction in energy losses and better thermal performance with a much smaller volume compared to traditional silicon-based devices.
- PECTA explored estimates of the potential global electricity savings for applications including uninterruptable power supplies (UPSs) in data centres, photovoltaic inverters, low-voltage industrial variable speed drives (VSDs), electric vehicle charging stations, inverters for battery storage and laptop chargers in the 2023 PECTA report ***Energy saving potential of WBG-commercial power converters in different applications.*** Based on current application installation levels, the potential for global electricity savings - switching from silicon-based to WBG technologies – are considerable, exceeding 120 TWh/year. The largest current potential is for low-voltage industrial VSDs.
- The adoption of WBG semiconductors in industrial VSDs presents multiple advantages, including improved efficiency, reduced cooling requirements and smaller form factors. These benefits collectively contribute to lower operational costs and increased performance.
- The adoption of WBG VSDs in the industry, despite their numerous advantages, faces several challenges. Ongoing research and development efforts continue to address these, aiming to reduce cost, improve reliability and expand the support infrastructure for WBG technology. By documenting these improvements, EMSA in cooperation with PECTA will develop a White Book by 2028, aiming to address the barriers to the adoption of SiC and GaN for industrial VSDs. The underlying WBG Research Roadmap schematic reflecting the different research topics is shown on the following page.

MORE INFORMATION

Published March 2025

Further information is available by contacting the coordinator of the upcoming White Book Andrea Vezzini **andrea.vezzini@bfh.ch** or the Chair of EMSA and PECTA Roland Brüniger **roland.brueniger@brueniger.swiss**.

Key Findings

Largest WBG technology energy saving potential is in industrial variable speed drives

PECTA's findings indicate substantial annual global electricity savings, exceeding 120 TWh, equivalent to around twice Switzerland's current electricity demand. The bulk of the savings, 103 TWh/year, are attributable to industrial VSDs. The total savings potential is conservative in nature, since it does not account for all WBG applications or potential future growth in sectors like photovoltaics. Despite the conservative nature of the potential estimates and uncertainties, the findings underscore WBG power electronics' important role in achieving global energy savings through increased energy efficiency.

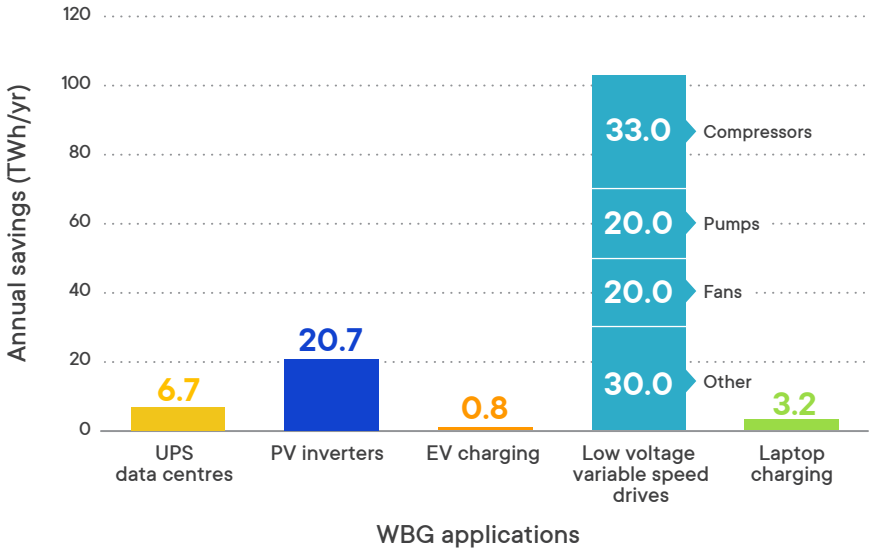

Figure 1: Potential energy savings for different applications in the year 2021.
As a comparison, a 1.2 GW nuclear power plant can produce about 10 TWh/year.
Note: UPS: uninterruptable power supply, PV: photovoltaic, EV: electric vehicle

WBG Industrial Variable Speed Drives Research Roadmap

The WBG Industrial VSDs Research Roadmap serves as a planning and coordination tool for input to the upcoming White Book on Wide Bandgap Semiconductors for Industrial Variable Speed Drives. It details the aspects to be considered in ongoing and planned research activities in fields directly related to the White Book. Special emphasis is placed on the applied and economic aspects of using WBG semiconductor-based industrial VSDs.

Research topics	Themes
RT1: Application readiness	▪ Cost comparison on component level ▪ Cost comparison on system level ▪ Cost comparison on holistic level ▪ Production capacity and availability ▪ Supply chain challenges
RT2: Design and implementation	▪ Comparison of WBG multilevel topologies ▪ Potential of alternative topologies ▪ Requirements and design of input and output filter design and topologies ▪ Operational parameter optimisation for optimal efficiency
RT3: Reliability and durability	▪ State of the art prediction of MTBF (mean time between failure) ▪ Methods for WBG reliability and duration testing ▪ Advances in modelling of WBG power semiconductor ▪ Standard and advanced thermal optimisation technologies for WBG power semiconductors
RT4: Risks to equipment	▪ Impact on bearings and insulation aging ▪ Impact on EMC (electromagnetic compatibility) testing and measures ▪ Increased measurement equipment accuracy for WBG industrial VSD testing

Figure 2: WBG industrial variable speed drives Research Roadmap 2024 - 2028